Electronic Version
Stylesheet Version v1.1.1

Claims

[c1] A subarray beamformer for a multi-beam phased array antenna comprising:
a plurality of phased array antenna beamforming layers comprising;
a first beamforming layer having a first plurality of combiners in a first orientation and combining a first set of signals to form a second set of signals; and
a second beamforming layer having a second plurality of combiners in a second orientation coupled to and opposing said first plurality of combiners, said second plurality of combiners combining said second set of signals to form at least one first combined signal.

[c2] A beamformer as in claim 1 wherein said first plurality of combiners are in a first unidirectional orientation and said second plurality of combiners are in a second unidirectional orientation orthogonal to said first unidirectional orientation.

[c3] A beamformer as in claim 1 wherein said plurality of phased array antenna beamforming layers further comprise:
a third beamforming layer having a third plurality of

combiners in a third orientation and combining a third set of signals to form a forth set of signals; and

a forth beamforming layer having a forth plurality of combiners in a forth orientation coupled to and opposing said third plurality of combiners, said forth plurality of combiners combining said forth set of signals to form at least one second combined signal.

[c4] A beamformer as in claim 3 wherein said third plurality of combiners are in a third unidirectional orientation and said forth plurality of combiners are in a forth unidirectional orientation orthogonal to said third unidirectional orientation.

[c5] A beamformer as in claim 3 wherein said first beamforming layer and said forth beamforming layer are formed as a single beamforming layer.

[c6] A beamformer as in claim 3 wherein said second beamforming layer and said third beamforming layer are formed as a single beamforming layer.

[c7] A beamformer as in claim 3 wherein said forth beamforming layer comprises fewer combiners than said third beamforming layer.

[c8] A beamformer as in claim 1 wherein said second beamforming layer comprises fewer combiners than said first

beamforming layer.

[c9] An assembly as in claim 1 wherein said subarray beamformer comprises fewer beamforming layers than a quantity of radiating elements coupled thereto.

[c10] A beamformer as in claim 1 wherein said plurality of phased array antenna beamforming layers comprise approximately less than or equal to four beamforming layers.

[c11] A beamformer as in claim 1 wherein each combiner within said first plurality of combiners and said second plurality of combiners combine signals received from each tile within a beamforming subarray of tiles.

[c12] A subarray beamformer for a multi-beam phased array antenna comprising:
a plurality of phased array antenna beamforming layers comprising;
a second beamforming layer having a second plurality of dividers in a second orientation and dividing at least one first combined signal to form a second set of signals; and
a first beamforming layer having a first plurality of dividers in a first orientation coupled to and opposing said second plurality of dividers, said first plurality of dividers

dividing said second set of signals to form a first set of signals.

[c13] A beamformer as in claim 12 wherein said first plurality of dividers are in a first unidirectional orientation and said second plurality of dividers are in a second unidirectional orientation orthogonal to said first unidirectional orientation.

[c14] A beamformer as in claim 12 wherein said plurality of phased array antenna beamforming layers further comprise:

a forth beamforming layer having a forth plurality of dividers in a forth orientation and dividing at least one second combined signal to form a forth set of signals; and

a third beamforming layer having a third plurality of dividers in a third orientation coupled to and opposing said forth plurality of dividers, said third plurality of dividers dividing said forth set of signals to form a third set of signals.

[c15] A beamformer as in claim 14 wherein said third plurality of dividers are in a third unidirectional orientation and said forth plurality of dividers are in a forth unidirectional orientation orthogonal to said third unidirectional orientation.

[c16] A beamformer as in claim 14 wherein said first beamforming layer and said forth beamforming layer are formed as a single beamforming layer.

[c17] A beamformer as in claim 14 wherein said second beamforming layer and said third beamforming layer are formed as a single beamforming layer.

[c18] A beamformer as in claim 14 wherein said forth beamforming layer comprises fewer dividers than said third beamforming layer.

[c19] A beamformer as in claim 12 wherein said second beamforming layer comprises fewer dividers than said first beamforming layer.

[c20] An assembly as in claim 12 wherein said subarray beamformer comprises fewer beamforming layers than a quantity of radiating elements coupled thereto.

[c21] A beamformer as in claim 12 wherein said plurality of phased array antenna beamforming layers comprise approximately less than or equal to four beamforming layers.

[c22] A beamformer as in claim 12 wherein each divider within said first plurality of dividers and said second plurality of dividers divide signals for each tile within a beamforming

subarray of tiles.

[c23] A multi-beam phased array antenna assembly comprising:
a plurality of radiating elements receiving a plurality of beams having a first set of signals;
a common structure coupled to said plurality of radiating elements;
a plurality of signal conditioners coupled to said common structure; and
a subarray beamformer coupled to said plurality of signal conditioners and comprising;
a plurality of phased array antenna beamforming layers comprising;
a first beamforming layer having a first plurality of combiners in a first orientation and combining said first set of signals to form a second set of signals; and
a second beamforming layer having a second plurality of combiners in a second orientation coupled to and opposing said first plurality of combiners, said second plurality of combiners combining said second set of signals to form at least one first combined signal.

[c24] An assembly as in claim 23 further comprising a cover coupled to said subarray beamformer.

[c25] An assembly as in claim 23 wherein said plurality of

phased array antenna beamforming layers further comprise:

a third beamforming layer having a third plurality of combiners in a third orientation and combining a third set of signals to form a forth set of signals; and

a forth beamforming layer having a forth plurality of combiners in a forth orientation coupled to and opposing said third plurality of combiners, said forth plurality of combiners combining said forth set of signals to form at least one second combined signal.

[c26] An assembly as in claim 23 wherein said subarray beamformer comprises fewer beamforming layers than a quantity of radiating elements within said plurality of radiating elements.

[c27] An assembly as in claim 23 wherein said plurality of phased array antenna beamforming layers comprise approximately less than or equal to four beamforming layers.

[c28] An assembly as in claim 23 wherein said plurality of phased array antenna beamforming layers comprise approximately two beamforming layers.

[c29] A multi-beam phased array antenna assembly comprising:

a plurality of radiating elements transmitting a plurality of beams having a first set of signals;

a common structure coupled to said plurality of radiating elements;

a plurality of signal conditioners coupled to said common structure; and

a subarray beamformer coupled to said plurality of signal conditioners and comprising;

a plurality of phased array antenna beamforming layers comprising;

a second beamforming layer having a second plurality of dividers in a second orientation and dividing at least one first combined signal to form a second set of signals; and

a first beamforming layer having a first plurality of dividers in a first orientation coupled to and opposing said second plurality of dividers, said first plurality of dividers dividing said second set of signals to form said first set of signals.

[c30] An assembly as in claim 29 further comprising a cover coupled to said subarray beamformer.

[c31] An assembly as in claim 29 wherein said plurality of phased array antenna beamforming layers further comprise:

a forth beamforming layer having a forth plurality of di-

viders in a forth orientation and dividing at least one second combined signal to form a forth set of signals; and

a third beamforming layer having a third plurality of dividers in a third orientation coupled to and opposing said forth plurality of dividers, said third plurality of dividers dividing said forth set of signals to form a third set of signals.

[c32] An assembly as in claim 29 wherein said subarray beamformer comprises fewer beamforming layers than a quantity of radiating elements within said plurality of radiating elements.

[c33] An assembly as in claim 29 wherein said plurality of phased array antenna beamforming layers comprise approximately less than or equal to four beamforming layers.

[c34] An assembly as in claim 29 wherein said plurality of phased array antenna beamforming layers comprise approximately two beamforming layers.

[c35] A satellite having a multi-beam phased array antenna assembly comprising;

a plurality of radiating elements receiving a plurality of beams having a first set of signals;

a common structure coupled to said plurality of radiating elements;

a plurality of signal conditioners coupled to said common structure; and

a subarray beamformer coupled to said plurality of signal conditioners and comprising;

a plurality of phased array antenna beamforming layers comprising;

a first beamforming layer having a first plurality of combiners in a first orientation and combining said first set of signals to form a second set of signals; and

a second beamforming layer having a second plurality of combiners in a second orientation coupled to and opposing said first plurality of combiners, said second plurality of combiners combining said second set of signals to form at least one first combined signal.

[c36] A satellite as in claim 35 wherein said subarray beamformer comprises fewer beamforming layers than a quantity of radiating elements within said plurality of radiating elements.

[c37] A satellite having a multi-beam phased array antenna assembly comprising:

a plurality of radiating elements transmitting a plurality of beams having a first set of signals;

a common structure coupled to said plurality of radiating

elements;

a plurality of signal conditioners coupled to said common structure; and

a subarray beamformer coupled to said plurality of signal conditioners and comprising;

a plurality of phased array antenna beamforming layers comprising;

a second beamforming layer having a second plurality of dividers in a second orientation and dividing at least one first combined signal to form a second set of signals; and

a first beamforming layer having a first plurality of dividers in a first orientation coupled to and opposing said second plurality of dividers, said first plurality of dividers dividing said second set of signals to form said first set of signals.

[c38] A satellite as in claim 37 wherein said subarray beamformer comprises fewer beamforming layers than a quantity of radiating elements within said plurality of radiating elements.

[c39] A method of forming a multi-beam phased array antenna assembly comprising:

manufacturing a common structure configured to couple a plurality of radiating elements to a plurality of signal conditioners;

coupling a beamforming board to said plurality of signal conditioners; and

encasing said plurality of signal conditioners and said beamforming board in said common structure.

[c40] A method as in claim 39 further comprising coupling a plurality of tile elements between said plurality of radiating elements and said beamforming board and within said common structure.